User Manual
DA14585 IoT Multi Sensor Development Kit Hardware Design
UM-B-095

Abstract
This document describes the hardware design of DA14585 IoT Multi Sensor development kit, which is based on Dialog Semiconductor’s DA14585 Bluetooth® Low Energy SoC. This development kit includes an accelerometer/gyro sensor, digital microphone, Gas (CO2) sensor, and an infrared proximity combined with an ambient light sensor in a single package.
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1 Terms and Definitions

ALS  Ambient Light Sensor
APDU  Application Protocol Data Unit
AVG  Average
BLE  Bluetooth Low Energy
BOM  Bill of Materials
CIB  Communication Interface Board
DCXO  Digitally Controlled Crystal Oscillator
e-CO2  Equivalent CO2
ESR  Equivalent Series Resistance
FW  Firmware
HW  Hardware
IAQ  Indoor Air Quality
IFA  Inverted-F Antenna
IR  Infrared
IoT  Internet of Things
JTAG  Joint Test Action Group (test interface)
LED  Light Emitting Diode
L2CAP  Logical Link Control and Adaptation Layer Protocol
MSK  Multi Sensor development kit
NP  Non-Populated
PA  Power Amplifier
PCM  Pulse Code Modulation
PDM  Pulse Density Modulation
RF  Radio Frequency
SoC  System on Chip
SIG  Special Interest Group
SPI  Serial Peripheral Interface
UART  Universal Asynchronous Receiver/Transmitter
USB  Universal Serial Bus
VOC  Volatile Oxide Compound

2 References

[2] AN-B-027, Designing printed antennas for Bluetooth® Smart, Application Note, Dialog Semiconductor
3 Introduction

Today's Internet of Things (IoT) market is extremely vibrant and promising. Various applications keep appearing on the market. They are expected to contain as many sensors as possible while consuming minimum power. Dialog's DA14585 IoT Multi Sensor development kit (MSK) uses components that consume low power and allows the development of IoT applications to offer a wide range of products and to react to the market fast. Using this development kit, users can develop numerous applications using the same hardware and support different use cases through the same firmware.

This document describes the hardware design for DA14585 IoT MSK. To learn about the architecture and configuration of the software reference applications, please refer to [5].

4 System Overview

4.1 Features

- Highly integrated DA14585 Bluetooth® Smart SoC from Dialog Semiconductor
- Stand-alone module
- Low cost due to printed antenna
- Low cost PCB
- Combined accelerometer/gyroscope sensor unit
- Combined sensors:
  - Accelerometer and gyroscope sensor unit
  - Gas and environmental (Temperature, Humidity and Pressure)
  - ALS and IR proximity
- Access to processor via JTAG and UART from the enclosure
- Programmable RF power up to +9.3 dBm
- Three LED indicators
- General purpose push button
- Expansion slots
- Powered by two low cost AAA alkaline batteries
4.2  Block Diagram

![Block Diagram of DA14585 IoT MSK from Top Level]

Figure 1: Block Diagram of DA14585 IoT MSK from Top Level
4.3 PCBA Overview

Figure 2: PCBA of a DA14585 IoT MSK: Top view
5 DA14585 IoT MSK

5.1 DA14585 SoC

DA14585 SoC is an optimized version of DA14580, offering a reduced boot time and supporting up to eight connections. It has a fully integrated radio transceiver and baseband processor for Bluetooth® Low Energy. It can be used as a stand-alone application processor or as a data pump in hosted systems.

The Bluetooth® Low Energy firmware includes L2CAP service layer protocols, Security Manager (SM), Attribute Protocol (ATT), Generic Attribute Profile (GATT), and Generic Access Profile (GAP). The firmware also supports all profiles published by the Bluetooth SIG as well as custom profiles.
5.1.1 DA14585 Pin Assignment

Table 1 shows GPIO pin assignment of DA14585 IoT MSK and related pin names for GPIO in the QFN40 package of DA14585.

Table 1: GPIO Pin Assignment for DA14585 IoT MSK

<table>
<thead>
<tr>
<th>Pin Name</th>
<th>Pin Assignment for GPIO</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>P0_0</td>
<td>SPI_CLK</td>
<td>SPI clock (Flash memory)</td>
</tr>
<tr>
<td>P0_1</td>
<td>CTRL_TX</td>
<td>PA’s control signal</td>
</tr>
<tr>
<td>Pin Name</td>
<td>Pin Assignment for GPIO</td>
<td>Comments</td>
</tr>
<tr>
<td>----------</td>
<td>------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>P0_2</td>
<td>CTRL_RX</td>
<td>PA's control signal</td>
</tr>
<tr>
<td>P0_3</td>
<td>SPI_CS</td>
<td>SPI chip select (Flash memory)</td>
</tr>
<tr>
<td>P0_4</td>
<td>UTX</td>
<td>UART transmit signal - Also connected on the expansion slots J8 and J9</td>
</tr>
<tr>
<td>P0_5</td>
<td>SPI_MISO/URX</td>
<td>SPI multiplexed with UART receive signal - Also connected on the expansion slots J8 and J9</td>
</tr>
<tr>
<td>P0_6</td>
<td>SPI_MOSI</td>
<td>SPI</td>
</tr>
<tr>
<td>P0_7</td>
<td>GPIOx3</td>
<td>External GPIO pin - To CTRL_PWM_BP via a non-pop resistor (R288)</td>
</tr>
<tr>
<td>P1_0</td>
<td>PDM_DATA</td>
<td>Audio interface (Mic)</td>
</tr>
<tr>
<td>P1_1</td>
<td>DRDY_AK09915</td>
<td>Data ready pin for the AK09915 magneto module</td>
</tr>
<tr>
<td>P1_2</td>
<td>INT_ICM42605</td>
<td>Interrupt pin for the ICM42605 accelerometer Multi Sensor gyro module</td>
</tr>
<tr>
<td>P1_3</td>
<td>PB1</td>
<td>Push button</td>
</tr>
<tr>
<td>P2_0</td>
<td>PDM_CLK</td>
<td>Audio interface (Mic)</td>
</tr>
<tr>
<td>P2_1</td>
<td>SPI_CS1</td>
<td>Chip select for the SPI the ICM40605 accelerometer Multi Sensor gyro module</td>
</tr>
<tr>
<td>P2_2</td>
<td>GPIOx</td>
<td>External GPIO pin</td>
</tr>
<tr>
<td>P2_3</td>
<td>INT_VCNL4010</td>
<td>Interrupt pin for the VCNL4010 optical sensor module</td>
</tr>
<tr>
<td>P2_4</td>
<td>SPI_CS2</td>
<td>Chip select for the SPI, connected to the testing connector for external use (additional sensor)</td>
</tr>
<tr>
<td>P2_5</td>
<td>SDA</td>
<td>I2C data (AK09915 magneto, Optical sensor module, GPIO expander)</td>
</tr>
<tr>
<td>P2_6</td>
<td>SCK</td>
<td>I2C clock (AK09915 magneto, Optical sensor module, GPIO expander)</td>
</tr>
<tr>
<td>P2_7</td>
<td>SPI_CS3</td>
<td>Chip select magneto (AK09915)</td>
</tr>
</tbody>
</table>
Pin Name | Pin Assignment for GPIO | Comments
---|---|---
P2_8 | Buzzer( Multi Sensor) | Buzzer
P2_9 | CTRL_PWM | PWM signal for PA power control
P3_0 | GPIOx2 | External GPIO pin - To the non-populated push button

### 5.1.2 DA14585 Power Pins

The power management subsystem of DA14585 SoC consists of:

- **VBAT1V**: INPUT.
  - Battery connection for an alkaline or a NiMH battery (1.5 V).
  - Power input in boost configuration only.
  - For buck configuration, this pin is shorted to GND.
- **VBAT3V**: INPUT/OUTPUT.
  - Battery connection for a single coin battery (3 V) or dual AAA batteries (2 × 1.5 V).
  - Power input in buck configuration only.
- **SWITCH**: INPUT/OUTPUT.
  - Connection for the external inductor of the DC-DC converter.
- **VDCDC**: Output of the DC-DC converter.
- **VDCDC_RF**: Supply input of the Bluetooth radio.
- **VDD**: INPUT.
  - This pin is used for testing purposes only.

The power supply of the DA14585 IoT Multi Sensor development kit includes:

- **Battery type**: Two standard non-rechargeable AAA batteries.
- **DC-DC converter**: The internal DC-DC converter has been configured to operate in Buck mode.
- **Power ON/OFF switch**: This reference design is equipped with a power ON/OFF switch.
- The track length between the VDCDC pin and the VDCDC_RF pin on the PCB should be at least 7 mm long.

### 5.2 Flash Memory

DA14585 uses an external Serial NOR Flash memory (Figure 5) to mirror its contents to RAM and execute the content. The Flash memory type used is MX25R2035FZU1L0:

- 2 Mbit QSPI Flash memory, operated in single I/O mode
- Operating voltage: 1.65 V to 3.6 V for read, erase, and program operations
- 8USON package
Please notice that a pull-up resistor has been added on the chip select (CS) pin. The reason is that during power-up and power-down, the pin CS needs to follow the voltage applied to the pin VCC to keep the device not selected.

![Diagram of the Flash memory](image)

**Figure 5: Serial NOR Flash Memory**

### 5.3 Crystal Oscillators

DA14585 SoC has two Digitally Controlled Crystal Oscillators (DCXO), one at 16 MHz (XTAL16M) and the other at 32.768 kHz (XTAL32K). XTAL32K has no trimming capabilities and is used as the clock for the Extended/Deep Sleep modes. XTAL16M can be trimmed.

The crystals used on the DA14585 IoT Multi Sensor development kit are specified in Table 2 and Table 3.

**Table 2: Y1 (16 MHz Crystal) Characteristics**

<table>
<thead>
<tr>
<th>Reference Designator</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part Number</td>
<td>7M-16.000MEEQ-T</td>
</tr>
<tr>
<td>Frequency</td>
<td>16 MHz</td>
</tr>
<tr>
<td>Accuracy</td>
<td>±10 ppm</td>
</tr>
<tr>
<td>Load Capacitance (CL)</td>
<td>10 pF</td>
</tr>
<tr>
<td>Shunt Capacitance (C0)</td>
<td>3 pF</td>
</tr>
<tr>
<td>Equivalent Series Resistance (ESR)</td>
<td>100 Ω</td>
</tr>
<tr>
<td>Drive Level (PD)</td>
<td>50 µW</td>
</tr>
</tbody>
</table>
Table 3: Y2 (32 kHz Crystal) Characteristics

<table>
<thead>
<tr>
<th>Reference Designator</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part Number</td>
<td>ABS06-32.768KHz-9-T</td>
</tr>
<tr>
<td>Frequency</td>
<td>32.768 kHz</td>
</tr>
<tr>
<td>Accuracy</td>
<td>±20 ppm</td>
</tr>
<tr>
<td>Load Capacitance (CL)</td>
<td>9 pF</td>
</tr>
<tr>
<td>Shunt Capacitance (C0)</td>
<td>1.2 pF</td>
</tr>
<tr>
<td>Equivalent Series Resistance (ESR)</td>
<td>90 kΩ</td>
</tr>
<tr>
<td>Drive Level (PD)</td>
<td>0.1 to 0.5 µW</td>
</tr>
</tbody>
</table>

5.4 Power Amplifier

The amplifier circuit is the SKY66111-11 from Skyworks. The SKY66111-11 is a fully integrated RF Front End Module (FEM) designed for Smart Energy applications. The device provides a PA and digital controls compatible with 1.7 V to 5 V CMOS levels. The basic characteristics for the SKY66111-11 are:

- TX Power: 10 dBm
- TX current: 10 mA
- RX sensitivity: SoC Multi Sensor1 (see Note 1)
- RX current: 1 µA
- Sleep current < 1 µA
- Supply operation: 1.8 to 5 V
- CTX and CRX control signals
- RX bypass
- One antenna port

Note 1 The FEM presents around 1dB insertion loss compared to the case where no PA is used.
5.4.1 Control Signals

5.4.1.1 RF Control Signals

The SKY66111-11 is controlled by CTX and CRX control signals. Their functionality is explained in Table 4.
Table 4: Truth Table for SKY66111-11

<table>
<thead>
<tr>
<th>Mode</th>
<th>CTX</th>
<th>CRX</th>
<th>BIAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sleep mode</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Receive (RX) mode</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Transmit (TX) mode</td>
<td>1</td>
<td>0</td>
<td>1 (See Note 2)</td>
</tr>
<tr>
<td>Non-permissible state (See Note 3)</td>
<td>1</td>
<td>1</td>
<td>X</td>
</tr>
</tbody>
</table>

Note 2  Analog voltage control for PA output power.
Note 3  This state will enable both the TX and RX paths. It is not permitted to operate in this state.

5.4.1.2  Power Control Signals

An external circuit is used to adjust the voltage level of the VCC power supply pin in SKY66111-11. By adjusting VCC, the output power of the PA can be regulated.

In general, the system can be configured to operate in three different modes:

- Programmable Output Power Mode:
  - A PWM signal with programmable duty cycle drives the external circuit.
  - The system operates in the range of 0 to +8 dBm by steps of 0, 2, 4, 6, and 8 dBm defined by the used duty cycle.
- Maximum Output Power Mode:
  - The system operates at the maximum power (+9.3dBm) as defined by the RBIAS.
- Bypass Mode: the PA is bypassed.

To configure the programmable output power mode and the maximum output power mode, the following two control signals are used:

- CTRL_PWM:
  - A PWM generated from DA14585 SoC with programmable duty cycle.
  - Uses timer0.
- CTRL_PWM_BP:
  - normal GPIO configured low or high (Accessed via the GPO expander)

To configure the bypass mode, the CTX and CRX inverted signals are used (see Note 4).

The signal configuration for each mode are described in Table 5.

Table 5: Signal Configurations for Power Control

<table>
<thead>
<tr>
<th>Mode</th>
<th>CTRL_PWM</th>
<th>CTRL_PWM_BP</th>
<th>CTX</th>
<th>CRX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Programmable Output Power Mode</td>
<td>PWM</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Maximum Power Mode</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Bypass Mode</td>
<td>Input pull-down</td>
<td>0</td>
<td>0 (see Note 4)</td>
<td>1 (see Note 4)</td>
</tr>
</tbody>
</table>
Note 4  CTX and CRX are configured as normal GPIO and not extracted from the diagnostic port. CTX is configured LOW and CRX HIGH during transmission.

5.5 Microphone

The SPK0838HT4H-B from Knowles is a miniature, high performance, low power, and top port silicon digital microphone with a single-bit PDM output.

Due to its high power consumption at sleep mode, it is supplied via a dedicated GPO from the GPIO expander.

Figure 8: Schematic of SPK0838HT4H Microphone

5.6 GPO Expander

Due to the high GPO demand in this reference design, a GPO expander is necessary. The used component is the low-power, I2C-controlled FXL6408UMX from Fairchild. It uses both power rails of 1.8 V and 3.3 V while its power consumption remains very low at only 1.5 µA (Sleep current).

Table 6: GPO Expander Pin Assignment

<table>
<thead>
<tr>
<th>GPO Expander Pin (FXL6408UMX)</th>
<th>Pin description</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPO 0</td>
<td>LED YELLOW</td>
<td>LED</td>
</tr>
<tr>
<td>GPO 1</td>
<td>MIC_SUP</td>
<td>Supply voltage for the PDM microphone</td>
</tr>
<tr>
<td>GPO 2</td>
<td>LED RED</td>
<td>LED</td>
</tr>
<tr>
<td>GPO 3</td>
<td>CTRL_PWM_BP</td>
<td>Controlling PA max power</td>
</tr>
<tr>
<td>GPO 4</td>
<td>LED GREEN</td>
<td>LED</td>
</tr>
</tbody>
</table>
5.7 Expansion Slots

DA14585 IoT MSK features two connection slots (J18 and J19) of a standard 2.54 mm pitch that enables developers to connect additional peripheral and sensors modules as it outputs the SPI with dedicated chip select SPI_CS2 and I2C interface. To provide users with programming and debugging capabilities, the JTAG/UART P0_4 and P0_5 GPIOs are also mapped on the J18 slot. Three spare DA14585 GPIOs and three from the GPO expander are also connected on these expansion slots. These are described in Table 1 and Table 6.

<table>
<thead>
<tr>
<th>GPO</th>
<th>GPO_EXT</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>5</td>
<td>GPO for usage connected to the expansion slot</td>
</tr>
<tr>
<td>6</td>
<td>2</td>
<td>GPO for usage connected to the expansion slot</td>
</tr>
<tr>
<td>7</td>
<td>3</td>
<td>GPO for usage connected to the expansion slot</td>
</tr>
</tbody>
</table>

Figure 9: Schematic of GPO Expander
5.8 Accelerometer/Gyroscope Sensor

The DA14585 IoT MSK employs the ICM42605 motion sensor from TDK InvenSense that combines a 3-axis gyroscope and a 3-axis accelerometer.

The ICM42605 features a 2 kB FIFO memory that can reduce the traffic on the serial bus interface and thus reduce power consumption, allowing the system processor to burst read sensor data and then go into a low-power mode.

The gyroscope supports eight independently-programmable full-scale range settings from ±15.625 dps to ±2000 dps, and the accelerometer supports four independently programmable full-scale range settings from ±2 g to ±16 g.

In full operation mode with the accelerometer and gyroscope enabled, the current consumption is typically 0.72 mA, while it drops down to 11 µA in sleep mode.

The ICM42605 module is connected to DA14585 via an SPI interface which supports speeds up to 24 MHz.
Table 7: Indicative Electrical Characteristics of ICM42605 Motion Sensor

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Voltage (VDD)</td>
<td>1.71</td>
<td>1.8</td>
<td>3.6</td>
<td>V</td>
</tr>
<tr>
<td>Supply Voltage (VDD I/O)</td>
<td>1.71</td>
<td>1.8</td>
<td>3.6</td>
<td>V</td>
</tr>
<tr>
<td><strong>Supply Currents</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6-Axis Gyroscope Multi Sensor</td>
<td>0.72</td>
<td></td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td>Accelerometer</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3-Axis Accelerometer</td>
<td>0.24</td>
<td></td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td>3-Axis Gyroscope</td>
<td>0.57</td>
<td></td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td>Sleep mode</td>
<td>11</td>
<td></td>
<td></td>
<td>uA</td>
</tr>
<tr>
<td><strong>Temperature</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>-40</td>
<td></td>
<td>85</td>
<td>°C</td>
</tr>
</tbody>
</table>

5.8.1 Additional (Non-Populated) Motion Sensor

For additional flexibility, the DA14585 IoT MSK is equipped with an additional PCB footprint (U11 as shown in Figure 24) of an alternative accelerometer/gyroscope sensor. This corresponds to the part number BMI160 of gyroscope/accelerometer from Bosch Sensortec. The SPI bus is shared with the
TDK sensor, meaning that ICM42605 along with its peripheral passive components have to be unsoldered before using BMI160.

Table 8: Motion Sensor Mounting Scenarios

<table>
<thead>
<tr>
<th>BMI160 as Motion Sensor</th>
<th>ICM42605 as Motion Sensor</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI160</td>
<td>Mounted</td>
</tr>
<tr>
<td>R283,R127,R282</td>
<td>Mounted</td>
</tr>
<tr>
<td>C36,C37</td>
<td>Not mounted</td>
</tr>
<tr>
<td>ICM42605</td>
<td>Not mounted</td>
</tr>
<tr>
<td>R253,R286,R278</td>
<td>Mounted</td>
</tr>
<tr>
<td>C120,C121,C132</td>
<td>Not mounted</td>
</tr>
</tbody>
</table>

5.9 Ambient Light and IR Proximity Sensor

The DA14585 IoT MSK has an ambient light and IR proximity sensor from Vishay, the VCNL4010, on board. This particular sensor is fully integrated as the IR LED emitter is included in the package. This optical sensor is connected to DA14585 via the I2C interface.

Potential applications include:

- Display contrast/brightness control
- Proximity switch for consumer electronics, display, and devices
- Dimming control
Table 9: Indicative Electrical Characteristics of VCNL4010 ALS and IR Sensor

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Voltage (VDD)</td>
<td>2.5</td>
<td></td>
<td>3.6</td>
<td>V</td>
</tr>
<tr>
<td>Supply Voltage IR Anode</td>
<td>2.5</td>
<td></td>
<td>3.6</td>
<td>V</td>
</tr>
<tr>
<td>Supply currents IR mode (Indicative)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 measurements per second, IRED current 20 mA</td>
<td>5</td>
<td></td>
<td>520</td>
<td>uA</td>
</tr>
<tr>
<td>250 measurements per second, IRED current 20 mA</td>
<td>520</td>
<td></td>
<td>520</td>
<td>uA</td>
</tr>
<tr>
<td>Supply currents IR mode (Indicative)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 measurements per second averaging = 1</td>
<td>2.5</td>
<td></td>
<td></td>
<td>uA</td>
</tr>
<tr>
<td>8 measurements per second averaging = 1</td>
<td>10</td>
<td></td>
<td></td>
<td>uA</td>
</tr>
<tr>
<td>Standby current consumption</td>
<td>1.5</td>
<td></td>
<td>2</td>
<td>uA</td>
</tr>
<tr>
<td>Ambient light resolution</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digital resolution (LSB count)</td>
<td>0.25</td>
<td></td>
<td></td>
<td>lx</td>
</tr>
<tr>
<td>Temperature</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>-40</td>
<td></td>
<td>85</td>
<td>°C</td>
</tr>
</tbody>
</table>

Note 5 As can be noted from the table above, this particular sensor operates with a minimum battery voltage of 2.5 V, therefore battery level warnings will appear on the Android application at the sensor readings when the battery level reach the minimum voltage threshold level.

5.10 Buzzer

The DA14585 IoT MSK employs the CSS-I4B20-SMT magnetic buzzer transducer from CUI INC. The buzzer is driven by the P2_8 GPIO via a transistor switch. Figure 14 shows the frequency response versus dB magnitude of the buzzer, with the largest magnitude being approximately 2.2 KHz.

![Buzzer Schematic](image-url)
5.11 Electronic Compass (Magnetometer)

The DA14585 IoT MSK employs an electronic compass (magnetometer) sensor from Asahi Kasei, the AK09915C. It incorporates:

- A magnetic sensor for detecting terrestrial magnetism in the X-axis, Y-axis, and Z-axis
- A sensor driving circuit
- A signal amplifier chain
- An arithmetic circuit for processing signals from each sensor off-loading the main processing unit
- Self-test function

The magnetic sensor is connected to the DA14585 via an SPI interface.
Table 10: Indicative Electrical Characteristics of AK09915C Magnetic Sensor

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Voltage (VDD)</td>
<td>1.7</td>
<td>3.0</td>
<td>3.6</td>
<td>V</td>
</tr>
<tr>
<td>Supply Voltage (VDD I/O)</td>
<td>1.65</td>
<td>3.0</td>
<td>3.6</td>
<td>V</td>
</tr>
</tbody>
</table>

Supply currents

| When magnetic sensor is driven | 2.1 | 3.5 | mA   |
| Self-test mode 3-Axis Accelerometer | 0.27 | 0.35 | mA   |
| Power down mode               | 3   | 6   | μA   |

Temperature

| Operating Temperature | -30 | 85  | °C   |

5.12 Environmental and Gas Sensor

The DA14585 IoT MSK employs the BME680 from Bosch Sensortec to detect environmental changes such as temperature, humidity, atmospheric pressure, and as well as e-CO2. This highly compacted sensor is suitable for monitoring indoor air quality and can detect air contamination from paint, furniture, garbage, and others using volatile oxide compounds (VOC) levels. From the VOC readings, two air quality parameters can be displayed using smart algorithms: the indoor air quality index (IAQ) and the e-CO2. This sensor is connected to DA14585 via an I2C interface.
Figure 16: Schematic of the Environmental and Gas Sensor
Table 11: Indicative Electrical Characteristics of BME680

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Voltage (VDD)</td>
<td>1.71</td>
<td>1.8</td>
<td>3.6</td>
<td>V</td>
</tr>
<tr>
<td>Supply Voltage (VDD I/O)</td>
<td>1.2</td>
<td>1.6</td>
<td>3.6</td>
<td>V</td>
</tr>
<tr>
<td><strong>Supply Currents</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current consumption during humidity measurement</td>
<td>340</td>
<td>450</td>
<td></td>
<td>uA</td>
</tr>
<tr>
<td>Current consumption during pressure measurement</td>
<td>714</td>
<td>849</td>
<td></td>
<td>uA</td>
</tr>
<tr>
<td>Current consumption during temperature measurement</td>
<td>350</td>
<td></td>
<td></td>
<td>uA</td>
</tr>
<tr>
<td>Current consumption during gas measurement</td>
<td>0.9</td>
<td></td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td>Current consumption during gas measurement, continuous mode</td>
<td>12</td>
<td></td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td>Sleep current</td>
<td>0.15</td>
<td>1</td>
<td></td>
<td>uA</td>
</tr>
<tr>
<td><strong>Temperature</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>-40</td>
<td></td>
<td>85</td>
<td>°C</td>
</tr>
</tbody>
</table>

5.13 Barometric Pressure Sensor

The DA14585 IoT MSK employs a high-accuracy, low-power, and waterproof barometric pressure sensor from TDK InvenSense, ICP10100, for atmospheric pressure detection. This barometric pressure sensor is connected to DA14585 via an I2C interface, although it is not mounted on this reference design (non-populated). This additional barometric pressure sensor is not supported by the software reference applications provided with the DA14585 IoT MSK, and users who would like to use this sensor need to do the soldering themselves.
Figure 17: Schematic of Barometric Sensor

Table 12: Indicative Electrical Characteristics of ICP10110

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Voltage (VDD)</td>
<td>1.71</td>
<td>1.8</td>
<td>1.89</td>
<td>V</td>
</tr>
<tr>
<td>Supply currents</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Idle state</td>
<td>1.0</td>
<td></td>
<td>2.5</td>
<td>μA</td>
</tr>
<tr>
<td>Measurement</td>
<td>210</td>
<td></td>
<td>300</td>
<td>μA</td>
</tr>
<tr>
<td>Temperature</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>-40</td>
<td></td>
<td>85</td>
<td>°C</td>
</tr>
</tbody>
</table>

5.14 System Power Supply Options

5.14.1 Battery Power Options

Figure 18 shows that the DA14585 IoT MSK can choose power supply between batteries and JTAG supply using the two-position ON/OFF switch (SW2).
The default power option for this development kit is to use two AAA batteries in the battery holder (BT1) to supply a 3 V voltage. In addition, the DA14585 MSK has an additional optional 3 V coin cell battery holder, although this battery holder (BT2) is not mounted on this reference design.
5.14.2 Alternative Power Options

Alternatively, the DA14585 IoT MSK can be powered by an external DCDC converter, XC9265A181MR from Torex. The input voltage comes directly from the battery input and the output of this particular DCDC converter is fixed to 1.8 V. This power option is deactivated by default. To activate this power option, users should mount the U28 circuitry, resistors R272 and R256 while dismount R257, as presented in Figure 22.

5.15 Printed Antennas

Printed antennas are of low cost, easy to manufacture, and able to provide diversity in polarization. The antenna used in this reference design is based on [2]. Figure 21 shows the directional dependence of the antenna (radiation pattern) of the printed IFA used in DA14585 IoT MSK.
Figure 20: The Printed IFA of a Reduced Size on PCB

Figure 21: Radiation Pattern of the Printed IFA of a Reduced Size
6 Schematics

Figure 22: Schematic 1 of DA14585 IoT MSK

Figure 23: Schematic 2 of DA14585 IoT MSK
7 PCB Layout

Figure 24: PCB of the DA14585 IoT MSK: Top View
8 Power Measurements

The following figures outline a series of power consumption measurements done on DA14585 MSK. Several scenarios were tested to provide some indicative power consumption figures. In these measurements the PA remains in bypass mode.

Figure 26 illustrated the power consumption of DA14585 IoT MSK when all the sensors are in sleep mode, while DA14585 SoC is in advertise mode and not connected to any mobile devices. The spike seen is from LED blinking. The average power consumption at sleep mode is 18.63 µA.
Figure 26: DA14585 Disconnected, All Sensors in Sleep Mode

Figure 27 shows the average power consumption with all sensors active and DA14585 IoT MSK in connected mode is 2.74 mA. DA14585 IoT MSK in connected mode means that it is connected with a mobile device which is providing the sensor reading to the user. With the gas sensor on, the total power consumption is approximately 14 mA.

Figure 27: DA14585 Connected, All Sensors Active

Figure 28 shows the power consumption when DA14585 IoT MSK is set in connected mode with the gas sensor turned off. The average power consumption drops to 1.47 mA.
Figure 28: DA14585 Connected, Gas Sensor Off Only

Figure 29 illustrates the power consumption when DA14585 IoT MSK is set in connected mode with all sensors except the environmental and gas sensor on. Compared to Figure 28, the average power consumption has been slightly decreased by 200 nA down to 1.45 mA, indicating the very low power consumption of the environmental sensor.

Figure 29: DA14585 Connected, Environmental and Gas Sensor OFF

Figure 30 shows that when DA14585 IoT MSK is set in connected mode with only the motion and magnetometer sensors on, the average power consumption is 1.38 mA.
Finally, Figure 31 shows that when DA14585 IoT MSK is set on connected mode with only the motion sensor on, the average total power consumption is merely 440 µA.
Table 13 shows the power measurement results in tabular form.

<table>
<thead>
<tr>
<th>Connection Mode</th>
<th>Active Sensors</th>
<th>Average Current Consumption Active (mA)</th>
<th>Average Current Consumption Sleep (µA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connected</td>
<td>All</td>
<td>2.74</td>
<td></td>
</tr>
<tr>
<td>Connected</td>
<td>Gas off only</td>
<td>1.47</td>
<td></td>
</tr>
<tr>
<td>Connected</td>
<td>Environmental and gas sensors off</td>
<td>1.45</td>
<td></td>
</tr>
<tr>
<td>Connected</td>
<td>Environmental and gas sensors, ALS, and IR sensors off</td>
<td>1.38</td>
<td></td>
</tr>
<tr>
<td>Connected</td>
<td>Only motion sensor ON</td>
<td>0.440</td>
<td></td>
</tr>
<tr>
<td>Disconnected, sleep mode</td>
<td>off</td>
<td></td>
<td>18.63</td>
</tr>
</tbody>
</table>

9 Enclosure

![Figure 32: DA14585 IoT MSK Enclosure: Top View](image)
9.1 Adjust IR Proximity Sensor Performance inside the Enclosure

Once the PCBA board of DA14585 IoT MSK is placed inside the enclosure, the proximity readings from the ALS and IR proximity sensor need to be adjusted to the lightning constraints imposed by the enclosure and it can be done by the Dialog IoT Sensors app that accompanies DA14585 IoT MSK.
**Figure 35** shows the front app panel of various sensor readings after the app is connected to DA14585 IoT MSK.

To adjust the ALS and IR proximity sensor, follow the following steps:

1. Press the “STOP” icon at the top right corner to stop all sensors.
2. Choose the menu at the top left corner, and the menu appears (Figure 36).
3. Choose “Settings” and the settings menu appears (Figure 37).
4. In the settings menu, choose “**Basic settings**” and scroll down to “**Reset to defaults**” (Figure 38). The values of the proximity hysteresis have now been adjusted for proper IR proximity functionality.

![Menu Panel of Dialog IoT Sensors APP](image)
Figure 37: Settings Menu of Dialog IoT Sensors App

Figure 38: Choices of Basic Settings in Dialog IoT Sensors App
10 Configuration of the Debugging Interface

The DA14585 IoT MSK has a dedicated debugging port (Figure 33), which can be used by both JTAG and UART debugging ports on DA14585 SoC.

The USB-to-JTAG and USB-to-UART functions are implemented by an external Communication Interface Board (CIB) shown in Figure 39. This CIB has a SEGGER chip running the JLink-OB firmware.

The CI
B performs the following functions:

- Connecting the PC to the DA14585 JTAG port, or
- Connecting PC to the DA14585 UART port (full UART is possible but it shall be enabled on the PC driver)
- Hardware RESET capability. Note that the RESET signal is active high.

Users should enforce the following on-board settings (Figure 39) to program/debug the DA14585 IoT MSK board:

- Set the ON/OFF switch (11) of the CIB to ON to power the DA14585 IoT MSK from the CIB
- Connect the USB cable to the mini USB connector (13)
- Connect an IDC-10 cable to the 1.27 mm pitch header (8) on the CIB
- Connect the other end of the IDC-10 cable to the debugging port on the bottom of the DA14585 IoT MSK
- Populate the jumper at J16 header (6)

The connection between the CIB and DA14585 IoT MSK is shown in Figure 40.
**Figure 40: Connection between DA14585 IoT MSK and the CIB**

**Note 6**  During programming/debugging, the ON/OFF switch should be set at OFF to have the DA14585 IoT MSK powered by JTAG, because users should program the development kit or download the firmware via the CIB without the two AAA batteries.
## Revision History

<table>
<thead>
<tr>
<th>Revision</th>
<th>Date</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>06-Aug-2018</td>
<td>Added section 9.1</td>
</tr>
<tr>
<td>1.0</td>
<td>03-Aug-2018</td>
<td>Initial version.</td>
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Status Definitions

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<tbody>
<tr>
<td>DRAFT</td>
<td>The content of this document is under review and subject to formal approval, which may result in modifications or additions.</td>
</tr>
<tr>
<td>APPROVED</td>
<td>The content of this document has been approved for publication.</td>
</tr>
</tbody>
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